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TO: Region Engineers
Region Delivery Engineers
TSC Managers
Resident/Project Engineers
Region Construction Engineers

FROM: Larry E. Tibbits
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SUBJECT: Bureau of Highway Instructional Memorandum 2004-12
Michigan Test Method 321 – 04, Determining Specific Gravity and Absorption
of Fine Aggregates

The referenced test method has been modified to more accurately state the testing procedure and to clarify the validation and reporting of test results. This revised method, a copy of which is attached, is to be implemented for the 2004 construction season and will be incorporated into the MDOT Michigan Test Methods when that publication is updated later this year.

Sections 8.4 through 8.6 and the associated calculations have been modified to call for analyzing two smaller samples of fine aggregate, comparing the results to validate the test, then averaging the two results to determine the final reported test results. The revised test method has been evaluated by MDOT and industry testing personnel, and has been found to be easier to perform while showing no significant difference in the results.

Please refer all questions regarding the modification to MTM 321 Determining Specific Gravity and Absorption of Fine Aggregates to the Construction and Technology Support Area's Bituminous Services Group at 517-322-5293 or 517-322-4967.

Chief Operations Officer

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Attachment

BOHD:C/T:JAR:kab

Index: Materials

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**MICHIGAN TEST METHOD
FOR
DETERMINING SPECIFIC GRAVITY AND
ABSORPTION OF FINE AGGREGATES**

1. Scope

This test method covers the determination of specific gravity and absorption of fine aggregate. The specific gravity may be expressed as bulk specific gravity, bulk specific gravity (SSD) (saturated-surface-dry) or apparent specific gravity. Bulk specific gravity (SSD) and absorption are based on aggregate after soaking in water for 24 hours.

2. Referenced Documents

2.1 ASTM Standards

- C 70 Test Method for Surface Moisture in Fine Aggregate
- C 127 Test Method for Specific Gravity and Absorption of Coarse Aggregate
- C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregate
- C 702 Practice for Reducing Field Samples of Aggregate to the Testing Size
- E 11 Specification for Wire-Cloth Sieves for Testing Purposes
- E 12 Terminology Relating to Density and Specific Gravity of Solids, Liquids, and Gases
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 AASHTO Standards

- T 84 Specific Gravity and Absorption of Fine Aggregates

2.3 MDOT Standards

- MTM 107 Method for Sampling Aggregates

3. Significance and Use

- 3.1 Bulk specific gravity is the characteristic generally used for calculation of the volume occupied by the aggregate in HMA mixtures which are proportioned or analyzed on an absolute volume basis.

4. Terminology

4.1 *Definitions*

- 4.1.1 *Absorption* - the increase in the weight of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry weight. The aggregate is considered *Adry*® when it has been maintained at a temperature of 200 °F ± 5 °F (93°C ± 3 °C) for sufficient time to remove all the uncombined water.

4.1.2 *Specific gravity* - the ratio of the mass (or weight in air) of a unit volume of a material to the mass of the same volume of water at stated temperatures. The terminology for specific gravity is based on ASTM E 12. Values are dimensionless.

4.1.2.1 *Apparent specific gravity* - the ratio of the weight in air of a unit volume of the impermeable portion of aggregate at stated temperature to the weight in air of an equal volume of water at a stated temperature.

4.1.2.2 *Bulk specific gravity (dry)* - the ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles but not including the voids between particles) at a stated temperature to the weight in air of an equal volume of water at a stated temperature.

4.1.2.3 *Bulk specific gravity (SSD)* - the ratio of the weight in air of a unit volume of aggregate, including the weight of water within the voids filled to the extent achieved by submerging in water for approximately 24 hours (but not including the voids between particles) at a stated temperature, compared to the weight in air of an equal volume of water at a stated temperature.

4.1.3 *Fine Aggregate* - For the purposes of this procedure, fine aggregate is defined as the aggregate passing the No. 8 (2.36 mm) sieve.

5. Summary of Test Method

5.1 A sample of washed, oven dry fine aggregate is immersed in water for approximately 24 hours to saturate the material. The water is then removed and the sample is exposed to a current of air and is stirred to remove the water from the surface of the particles. Two portions of the sample are placed in volumetric flasks and weighed. The flasks are filled with water, air bubbles are removed, and the samples are weighed again. Finally the samples are placed in pans, oven-dried, and weighed a third time. Using the weights thus obtained, and formulas in this test method, it is possible to calculate three types of specific gravity and absorption.

6. Apparatus

6.1 Balance - A weighing device having a capacity of 2 kg or more, sensitive to 0.1 g or less.

6.2 Two Pycnometers - Each being a volumetric flask of 500ml capacity.

6.3 Mold - A metal mold in the form of a frustum of a cone with the dimensions as follows: 1.57 inches \pm 0.12 inches (40 mm \pm 3 mm) inside diameter at the top, 3.54 inches \pm 0.12 inches (90 mm \pm 3 mm) inside diameter at the bottom, and

2.95 inches \pm 0.12 inches (75 mm \pm 3 mm) in height, with the metal having a minimum thickness of 0.03 inches (0.8 mm).

- 6.4 Tamper - A metal tamper weighing 340 g \pm 15 g and having a flat circular tamping face 1 inch (25 mm) \pm 0.12 inches (3 mm) in diameter.

7. Sampling

- 7.1 Obtain approximately 1200 g of fine aggregate from the sample using the applicable procedures described in Practice C 702.

8. Procedure

- 8.1 Dry the sample in a suitable pan or vessel to constant weight at a temperature of 230 °F \pm 5 °F (110 °C \pm 3 °C).

- 8.2 Allow the sample to cool to room temperature, then wash sample over a No. 200 (75 μ m) sieve until water runs clear. Place material retained on the No. 200 (75 μ m) sieve in a container and immerse in water at room temperature for a period of 24 \pm 4 hours.

- 8.3 Remove excess water from the washed sample being careful to avoid loss of material. Spread the sample on a flat non-absorbent surface exposed to a gently moving current of 60 to 85 °F (15 to 29 °C) air and stir frequently to secure homogeneous drying. When the test sample approaches a free flowing condition, follow the procedure in 8.3.1 to determine whether or not surface moisture is present on the fine aggregate particles. It is intended the first trial of the cone test will be made with some surface water in the sample. Continue drying with constant stirring and test at frequent intervals until the test indicates the sample has reached a surface-dry condition. **If the first trial of the surface moisture test indicates moisture is not present on the surface, it has dried past saturated-surface dry condition. This will invalidate the test and the material must be re-tested.**

8.3.1 Cone Test for Surface Moisture - **Hold the mold down firmly** on a smooth non-absorbent surface with the large diameter down. Place a portion of the partially dried fine aggregate loosely in the mold by filling it to overflowing. Remove loose material from around the outside of the base of the mold. Tamp the fine aggregate into the mold with 25 drops of the tamper. Each drop should start about 0.25 inches (5 mm) above the surface of the aggregate. Permit the tamper to fall freely on each drop. Adjust the starting height to the new surface elevation after each drop and distribute the drops over the surface. Lift the mold vertically. If surface moisture is still present, the fine aggregate will retain its shape. When the fine aggregate slumps slightly it indicates that it has reached a surface-dry condition.

- 8.4 Immediately introduce approximately 250 g of saturated surface-dry fine aggregate into each of two calibrated pycnometers. Weigh each pycnometer and

record each weight as $A_{\text{weight of saturated-surface dry test sample}}$. Record this and all subsequent weights to the nearest 0.1 g. Follow the rounding method described in ASTM E 29.

- 8.5 Fill each pycnometer with water to approximately 90% of capacity. Roll, invert, and agitate each pycnometer to eliminate all air bubbles (Note 1). Adjust the temperature of each pycnometer to $77^{\circ}\text{F} \pm 3^{\circ}\text{F}$ ($25^{\circ}\text{C} \pm 1.7^{\circ}\text{C}$) by immersion in circulating water and allow samples to settle for a minimum of five (5) minutes. Then remove the pycnometers from the circulating water and bring the water level in each of the pycnometers to the calibrated capacity. (Note 2) Determine the total weight of each of the pycnometers containing the sample and water. Record these weights as $A_{\text{weight of flask filled with sample and water to calibration mark}}$.

NOTE 1: It normally takes about 3 to 7 minutes to eliminate air bubbles.

NOTE 2: Dipping the tip of a paper towel into the pycnometer has been found to be useful in dispersing the foam that sometimes builds up when eliminating the air bubbles.

- 8.6 Remove the fine aggregate from each of the two pycnometers and place each sample into a separate ovenproof container. Be certain to remove all the material from the pycnometers, taking care not to lose any. Dry the material in an oven at a temperature of $200^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ($93^{\circ}\text{C} \pm 3^{\circ}\text{C}$) to a constant weight. Cool the samples until the aggregate has reached a temperature that is comfortable to handle. Weigh the samples and record as $A_{\text{weight of oven-dry test sample in air}}$. Complete the calculations according to Section 9 for each of the two samples (indicated by the subscript i in the formulae below).

9. Calculations

9.1 Specific Gravity:

- 9.1.1 Bulk Specific Gravity (Dry) - Calculate the bulk specific gravity 77°F (25°C), as follows:

$$\text{Bulk specific gravity (dry)} = J_i / (E_i + C_i - F_i)$$

Where:

J = weight of oven-dry test sample in air, g.

E = weight of flask filled with water to calibration mark

C = weight of saturated-surface dry test sample in air, g.

F = Weight of flask with sample and water to calibration mark, g.

- 9.1.2 Bulk Specific Gravity (SSD) - Calculate the bulk specific gravity, 77°F (25°C), on the basis of weight of saturated-surface-dry aggregate as follows:

$$\text{Bulk specific gravity (SSD)} = C_i / (E_i + C_i - F_i)$$

- 9.1.3 Apparent Specific Gravity - Calculate the apparent specific gravity 77 °F (25 °C), as follows:

$$\text{Apparent specific gravity} = J_i / (E_i + J_i - F_i)$$

- 9.2 Absorption - Calculate the absorption as a percent of the dry weight as follows:

$$\text{Absorption} = [(C_i - J_i) / J_i] \times 100$$

- 9.3 Compare the two sets of results obtained to the precision limits in Section 11. If the Single Operator Precision Acceptable Range of Two Results are exceeded on any parameter, the test is invalid and a retest must be performed.
- 9.4 If the results are valid, average the two results for specific gravity and for absorption. These are the results of this test method.

10. Report

- 10.1 Report specific gravity results to the nearest 0.001 and indicate the type of specific gravity, whether bulk (dry), bulk (saturated-surface-dry) or apparent.
- 10.2 Report the absorption results to the nearest 0.1%.

11. Precision

- 11.1 The criteria for judging the acceptability of the specific gravity test results obtained by this method are given in the following table:

Table 1: Precision Limits for Specific Gravity and Absorption

	Standard Deviation	Acceptable Range of Two Results
<i>Single-Operator Precision:</i>		
Bulk specific gravity (dry)	0.011	0.032
Bulk specific gravity (SSD)	0.0095	0.027
Apparent Specific gravity	0.0095	0.027
Absorption, %	0.11	0.31
<i>Multilaboratory Precision:</i>		
Bulk specific gravity (dry)	0.023	0.066
Bulk specific gravity (SSD)	0.020	0.056
Apparent Specific gravity	0.020	0.056
Absorption, %	0.23	0.66